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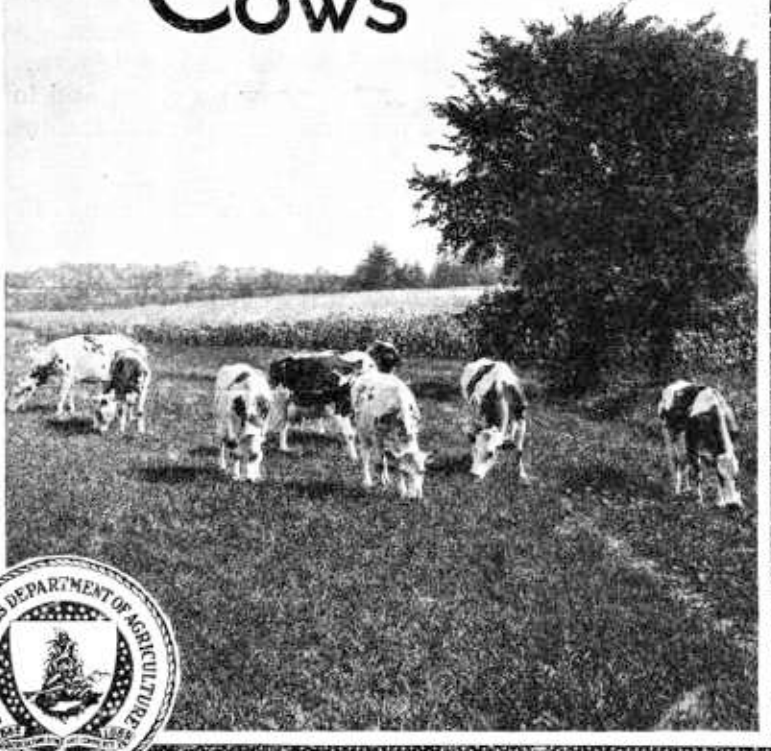
Feeding Dairy Cows



THE FEED of the dairy cow constitutes about one-half the expense of milk production. Profitable milk production, therefore, demands close attention to the matter of feed. The ration must be adequate in quantity, suitable in quality, but as low in cost as possible. The quantities of feed to be given the cow for most economical production have been determined with a fair degree of accuracy. The object of this bulletin is to state in simple terms some of the principles of dairy-cow nutrition and to assist the dairyman in preparing economical rations for his cows.

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FEEDING DAIRY COWS

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HOW A DAIRY COW USES HER FEED

THE RATION of a dairy cow is used for five main purposes, namely, maintenance, growth, body fat, development of fetus, and milk production.

A maintenance ration is an amount of feed equivalent to that needed to keep the cow at constant weight when not giving milk or carrying a calf. It is used to keep the vital organs functioning properly, to replace worn body tissue, to maintain body temperature, and to provide energy for muscular activity, such as standing or moving about. The maintenance ration must be considered somewhat as a necessary overhead expense. Apparently none of it, except perhaps some of the protein, contributes anything toward economic production; yet, as a general rule, it is the first to be used by the cow and certainly should be the first to be considered in compounding a ration.

An immature animal uses a portion of its feed for growth. For this reason it needs a larger ration than a mature animal of the same weight. The ration for growth requires somewhat more protein than does the maintenance ration.

The feed needed for body fat is of no considerable consequence except during the time when the cow is dry or nearly so; at this time she is storing up a reserve to be used after calving.

When the cow is carrying a calf she needs extra feed to provide for the development of the fetus and the membranes and fluids coexistent with pregnancy. The quantity of feed required for these purposes is not large but is sufficient to be considered.

Just after calving, and for three to six weeks thereafter, high producers do not consume sufficient feed to supply the nutrients needed for milk and for maintenance, and as a result they lose weight. Liberal feeding is desirable but only to the point of supplying the nutrients they can use without undue waste.

IMPORTANCE OF THE VARIOUS FEED CONSTITUENTS

PROTEINS

Proteins in the feed are used to make the proteins of milk, blood, lean meat, and all nitrogenous body tissues. They are used in the repair of parts broken down in the ordinary course of bodily activities. For the purposes enumerated no other constituent can take their place. In addition to these uses proteins can also be employed in making fat and providing energy.

Proteins are made up of various amino acids, sometimes called the protein building stones. If a cow is to produce all the milk of which she is capable by inheritance she must receive a sufficient amount of each of the various amino acids used for maintenance and milk production. Since different proteins contain different proportions of the amino acids, the cow needs not only an ample quantity of protein but also various kinds of this constituent. This will usually call for the feeding of materials derived from several species of plants. When the constitution of the proteins and the characteristics of the amino acids become better known it may be possible to reduce both the quantity of proteins and the sources from which they are obtained. All feeding standards specify an amount of digestible protein somewhat in excess of that found in milk. A moderate excess is not known to be detrimental to the health of the animal. Furthermore, since the proteins not used for milk production can be used to make fat or energy, they are not entirely wasted. The fact that in most dairy sections of the United States feeds high in protein are more expensive than those low in this constituent is probably the main reason for using a ration containing the smallest quantity needed for continuous high production.

CARBOHYDRATES

The principal substances in feeds making up carbohydrates are starches, sugars, and crude fiber. These are used to maintain body temperatures, to make body fat and milk fat, and to provide energy for every muscular activity, such as mastication, respiration, and locomotion. Crude fiber is the least digestible of these substances. Feeds containing more than 18 per cent of fiber in the dry substance may be classed as roughages, and those containing less as concentrates. Carbohydrates are more plentiful than proteins and are usually cheaper. This is one reason why it is generally unwise to use proteins for any purpose that carbohydrates will serve.

FATS

Fats in feeds are used for the same general purposes as carbohydrates, but on the basis of equal weights of each they are about two and one-fourth times as efficient as carbohydrates. They also lubri-

cate the digestive tract and aid in making a glossy coat. Since most rations are thought to contain fats in sufficient quantities for satisfactory nutrition, no special consideration need be given the fat content in the preparation of the ration.

MINERALS

Minerals comprise a variety of compounds which exert an important influence on many of the physiological processes of the animal body and are as necessary as the other constituents of the ration. They are used principally to aid digestion, to make bone, to provide the mineral matter in the milk, to build up the body, and to aid in the functioning of all organs in general.

Feed for cows must contain enough minerals of the proper kind, or they will draw upon their body stores and eventually decline in production. Possibly other ill effects also can be traced to lack of minerals. In some sections pregnant cows fed rations deficient in iodine are likely to give birth to calves afflicted with goiter.

WATER

Water is the great carrier of food material within the body of the animal. It makes blood a fluid so that it can circulate. Many substances must be dissolved in water before they can be absorbed from the digestive tract. Waste materials are dissolved in water and eliminated as urine and perspiration. By its evaporation from the skin and lungs water controls body temperatures. Water, then, is a necessary constituent of practically all excretions or secretions, including milk. Animals will live much longer without food than without water.

VITAMINS

The term " vitamin " is a group name for certain substances other than proteins, fats, carbohydrates, and minerals which occur in minute quantities in natural food materials. Those studied have been named A, B, C, D, and E, vitamin B probably being made up of two or more independent factors. Their chemical composition is not known. They are recognized by their effects rather than by their appearance or behavior. Vitamins are essential to the life and health of animals. As far as is known they are manufactured mainly by plants, though certain ones may be formed within the animal by irradiation or by the action of bacteria upon the contents of the digestive tract. Generally the vitamin requirements for keeping the dairy cow in good condition are fulfilled by the ordinary rations. Pasture grass and all fresh green forages contain relatively large quantities of vitamin D. Either this vitamin or some unidentified substance in the green plant assists in the assimilation of calcium.

Research work on vitamins has been mostly with small animals, such as rats, guinea pigs, and poultry. Results obtained with one species of animals are not always applicable to other species. Definite recommendation as to the preparation of dairy rations with respect to vitamins, therefore, can not be made until further research with dairy cattle is completed.

PROCESS OF DIGESTION

In order to give a better understanding of the principles underlying the practice of feeding dairy cows, it may be well to trace briefly the course of the feed through the digestive tract.

The cow's stomach is divided into four compartments. Apparently cows chew their feed and mix it with saliva only enough to permit it to be swallowed into the large compartment of the stomach known as the rumen or paunch. This compartment acts as a reservoir and softens the coarse feed through the action of body heat and mixing with water. It appears also that the action of certain bacteria in the paunch may be beneficial.

Cows chew their cud for the purpose of further reducing the size of the feed particles so that passage to the other compartments of the stomach may take place. Any feed that is in a sufficiently fine state of division may pass on directly without rechewing. The paunch is never empty; additional feed enters every time a cow eats, and the new and old materials are mixed. Although some of the roughage, such as hay, passes through the digestive tract in about 1½ days, some of it remains in the body for 10 days or more.

The next compartment of the stomach is known as the reticulum or honeycomb. Its contents are more watery than those of the paunch. It is here that foreign material, such as gravel and pieces of metal, collects and remains. Sometimes a sharp piece of wire or nail penetrates the wall of this compartment, with fatal results.

The third compartment is called the omasum or manyplies. Across it are divisions resembling leaves of a book, and it is between these leaves that the food passes. The contents of this compartment are much drier than those of the others.

Although some absorption of nutrients into the blood takes place through the walls of the first three compartments, their main function appears to be the preparation of the food for the action of the fourth and last compartment, or true stomach, known as the abomasum. It is here that the digestive juices act on the proteins and convert some of them into a state permitting their absorption through the walls of the stomach.

The food then enters the intestines, where it is further acted upon by the bile, pancreatic juice, and other juices, which digest the fats and carbohydrates as well as some of the proteins. Most of the food absorption takes place through the walls of the intestines.

CHARACTERISTICS OF FEEDS

Feeds vary considerably in composition. One lot of hay, for example, may contain a high percentage of the food constituents needed by the animal, whereas another lot of the same kind of hay and from the same cutting, but grown on a different part of the field or cured and handled in a different manner, may contain a low percentage of certain food elements. The dairyman may find also that whereas his cows have done well on a certain cutting of alfalfa, a sudden change to another cutting causes a decrease in the milk flow. Sudden and extreme changes in the ration, such as from all dry feed to all green feed or from a low-protein to a high-protein ration, may cause a temporary change in percentage of butterfat.

Variations in the composition of feeds, however, generally affect the quantity of milk production rather than the composition of milk. Feeding a ration rich in fat, for instance, does not permanently increase the percentage of butterfat in the milk, for this percentage, like that of all the other constituents of milk, is largely a matter of inheritance.

HAYS

The importance of good hay can hardly be overestimated. By good hay is meant hay that has been cut early and cured with the retention of much of its natural green color. Such hay contains more protein, less fiber, more leaves, and fewer stems than that cut late. It is also softer and more palatable. The mineral matter of green-cured hay is more completely used than that of hay which has become discolored through exposure to dew or rain.

Although legume hays are generally superior to the nonlegumes in content of protein and mineral matter and in palatability, much depends upon the soil on which the hays are grown and on the way the hays have been made. A grass hay, for instance, grown upon a soil that is rich in lime and phosphorus, cut early, and nicely cured, may be superior in many respects to a legume hay. A legume hay is not necessarily good because it is a legume, nor is a grass hay necessarily poor because it is a grass.

All dairymen, whether they raise their own hay or buy it, should be able to determine, by observation, the quality of the various classes and grades of hay, as given in the United States Department of Agriculture Handbook of Official Hay Standards, for 1928.

The following statement[1] made with reference to alfalfa-hay production and marketing may be applied in general to all hays:

> (1) Early cut, leafy, and properly cured alfalfa from any region has more feed value than overripe, stemmy, and properly cured alfalfa from the same region or any other region; (2) alfalfa from any region, so cured as to retain a high percentage of leaves, has more feed value than alfalfa from the same region or any other region that was so cured as to shatter a high percentage of leaves from the stems prior to baling; and (3) early cut, leafy, and properly cured alfalfa from any region has more feed value than early cut, severely bleached, and rain-damaged alfalfa from the same region or any other region. Similar comparisons and conclusions may be made with respect to the feed value of various cuttings.

LEGUME HAYS

Legume hays appear desirable for the proper nutrition of the dairy cow when pasture or other green feed is not available. In most sections of the United States they yield more nutrients per acre than do nonlegumes, and protein is obtained at a lower cost. Good legume hay is cured so as to retain its green color, is fine stemmed, and contains a large proportion of leaves to stems. Forty-four pounds of alfalfa leaves contain as much protein as 100 pounds of stems. For supplying vitamins, good legume hay and silage take the place to some extent of fresh, green forage.

Alfalfa is the best hay for dairy cows. (Fig. 1.) It is more palatable than clover, is more easily cured than the annual legumes, and

[1] United States Department of Agriculture, Bureau of Agricultural Economics. U. S. Standards Reflect the Approximate Value of Alfalfa, 5 pp. 1927. [Multigraphed.]

is more completely consumed when fed than is either soybean or cowpea hay. Wherever alfalfa grows successfully it should be raised in preference to any other legume.

Although cows will eat no more of the clovers than they will of the annual legumes, there is usually less waste in feeding the clovers on account of their finer stems. Because of their fine stems also they cure more readily, a fact which lessens the likelihood of damage from rains. The clovers are rather uncertain crops. The stand is sometimes poor, and they are subject to winterkilling. No doubt this fact is responsible for the usual practice of seeding timothy or other grass along with the clover for if the clover fails the farmer still has timothy.

FIGURE 1.—Properly cured alfalfa hay is a highly desirable dairy feed

Either soybeans or cowpeas can be raised successfully over a wide range of climatic and soil conditions. They grow on soils containing less lime than do the clovers or alfalfa, and they are especially valuable as catch crops for hay. The soybeans, being more upright in their growth and thus more easily harvested, are usually preferred to the cowpeas.

The Lespedeza hays, both the common and improved varieties, are coming into more general use in the South, especially on acid soils. They make excellent hay, and some very good yields on rich soil have been reported.

The first year's growth of the biennial sweetclover makes a very good hay. If allowed to reach considerable height before being mowed, however, it will be stemmy, and the leaves will shatter badly. The second year's growth should be used for pasture rather than as hay for the following reasons: (1) It grows so rapidly that in order

to get a reasonably fine hay it must be cut very early in the season when curing is difficult; and (2) while many farmers for a long time have fed second year's growth successfully, instances have been recorded where such hay contained some substance which prevented the normal clotting of blood and led to fatal hemorrhages in the animal.

GRASS HAYS

Grass hays include timothy, ryegrass, bluegrass, Sudan grass, sorghum, and others. As a rule these hays are less palatable than legume hays and contain less protein and mineral matter. For these reasons they are not so good as legume hays for milk production.

GRAIN HAYS

Grain hays include those made from the small cereals, such as oats, barley, wheat, and rye. For the best hay these cereals should be cut when the grain is in the milk. At this stage the cured leaves retain their green color and if carefully handled do not crumble badly. In composition the grain hays are similar to grass hays, being rather low in protein in proportion to the carbohydrates and fats. The awns on some varieties of barley and wheat make these hays decidedly undesirable for feeding.

MIXED HAYS

Although the Handbook of Official Hay Standards has a specific definition for mixed hay, for the purpose of this discussion any combination of a grass and a legume is called a mixed hay. Its composition is influenced by the kind and relative quantities of legumes and nonlegumes which it contains, the stage of maturity when cut, and the manner in which it is cured. Although early cut grass often contains as much protein as the legumes, it is safe to conclude that on the average mixed hays contain only about two-thirds as much protein as do the legumes.

The practice of using a mixture of legumes with some other crops is to be commended where the legumes on account of soil conditions or habits of growth can not be depended upon for hay when sown alone. Some of these mixtures are oats and vetch, wheat and vetch, oats and peas, Sudan grass and soybeans, as well as clover and timothy, and alfalfa and timothy. These can all be made into a good quality of hay.

STRAWS

The cereal straws are high in fiber, low in proteins and minerals, constipating, and lacking in palatability. Cows, however, will eat small quantities of these, especially oat straw, even when they have access to plenty of legume hay. Probably the consumption of a small quantity is beneficial.

CORN STOVER

The edible portion of corn stover is similar to timothy or other grass hay in composition, effects, and value. If the corn is cut rather

early and the stover is stored where it will not be leached by the fall and winter rains, it makes a fair feed. Even when carefully cured, however, it lacks the nutritive qualities desired in dairy feeds. Straws and corn stover must not be expected to take the place of legume hays in the ration.

SILAGES

All silages have the desirable quality of succulence, some are palatable, and some provide nutrients in a cheap form. All things considered, corn makes the best silage. It is very palatable, though low in protein and minerals. Other nonleguminous silages, such as sorghums and Sudan grass, are a little less palatable and contain less nutrients. Legumes with a water content between 50 and 70 per cent are successfully ensiled. To reduce the moisture content to the proper point it is often necessary to let them wilt thoroughly after mowing. They are higher than corn silage in protein and mineral matter but not so palatable. Sunflowers and certain other plants make silages that are less palatable than corn silage.

SOILING CROPS

Soiling crops, which are harvested and fed immediately in their fresh green state, are valuable as substitutes for pastures or as supplements to them. A cereal, Sudan grass, or a legume, or a combination of the cereal or Sudan grass with a legume, is most commonly used, but any palatable green feed may be fed. Soiling crops are similar to pasture in nutritive value.

ROOT CROPS AND OTHER SUCCULENTS

Most of the common root crops, such as mangels, beets, rutabagas, turnips, and carrots, are valuable dairy feeds. Because they are low in fiber and high in water content these feeds are sometimes spoken of as watery concentrates. Materials which may be fed in the place of silage or the root crops are apples, apple pomace, pumpkins, cull potatoes, sweetpotatoes, kales, wet sugar-beet pulp, and wet brewers' grains. The value of each depends largely upon the content of dry matter. Beet pulp and pumpkins are low in this respect, having only about one-third as much dry matter as sweetpotatoes and wet brewers' grains.

PASTURE

Pasture grass or other green forage appears desirable for continuous high milk production. Such material possesses a property which under certain conditions promotes the assimilation of mineral matter. A cow on good pasture is able to replenish the stores of minerals which are likely to have become depleted during the winter if an unsuitable grain mixture and a poor quality of roughage have been fed. Since pasture grass is bulky and watery, most cows are unable to eat enough of it alone to support a very large flow of milk. As the grass matures there is a steady decline in the percentage of protein and an increase in the content of dry matter and fiber.

CEREAL GRAINS

In general, cereal grains are palatable, rich in carbohydrates, low in fiber and minerals, comparatively low in protein, and high in total digestible nutrients. Corn stands at the head of the list in palatability and percentage of total digestible nutrients. Barley and the sorghums are almost as high in these respects. Oats have a higher fiber content than any of the other cereals but contain more protein than does corn or barley. Wheat is similar in composition and feeding value to corn, and when the price of wheat per pound is less than that of corn it will pay to substitute wheat for corn in grain mixtures for dairy cows. Rye is high in content of nutrients, but because it lacks palatability it is used very little as a dairy feed.

LEGUME SEEDS AND OIL MEALS

The legume seeds and so-called oil meals contain much protein and have a high nutritive value. The legume seeds used for dairy feed include the field pea, velvetbean, soybean, and peanut. The oil of the soybean and peanut is usually extracted and used commercially, the residue being used for feeding purposes. In that form they are similar in feeding value to linseed meal and cottonseed meal, which are also residues from the extraction of oil from the flax and cotton seeds, respectively. All these feeds except the velvetbean are palatable, but their high concentration makes it essential that they be fed with more bulky material. Cottonseed meal contains a comparatively large percentage of phosphorous, linseed meal and soybean meal somewhat less, and peanut meal the least of all.

BY-PRODUCTS

A number of by-products are used for feeding, but only the most important ones are here discussed.

Wheat bran contains much phosphorus, a medium amount of protein, and is of a bulky nature. These characteristics make it a valuable ingredient of all dairy rations.

Hominy feed is comparable with corn meal in nearly all respects. They are thought to be equal in feeding value pound for pound. Hominy feed is not so likely to heat and mold as is corn meal.

Corn-gluten feed is rather high in protein, averaging 20 per cent or more in the best grades. It is somewhat bulky and not quite so palatable as the two foregoing feeds.

Dried brewers' grains are similar to corn-gluten feed in composition, but they contain more fiber and less total nutrients.

Dried beet pulp is low in protein, bulky, and fairly palatable. After being soaked it is often fed in place of silage. Apparently cows are unlikely to be injured by eating too much of the wet pulp.

Both beet and cane molasses are very palatable and when mixed with some feeds ordinarily unpalatable cause them to be eaten more readily and completely. About two-thirds of the weight of molasses is sugar. Sometimes the price of molasses is so low that some feeders consider that the nutrient content alone justifies its purchase. Both kinds of molasses are laxative, that from the beet being more so than that from the sugarcane.

COMMERCIAL MIXED FEEDS

Commercial mixed feeds are being used by an ever-increasing number of dairymen. At present many excellent mixed feeds containing only high-quality ingredients are on the market. Laws governing the sale of mixed feeds require that the chemical composition be stated on the bag. An examination of this analysis will enable the buyer to form a fairly accurate opinion of the value of the feed. The lower the fiber content the more valuable the feed. A high fiber content indicates the presence of oat hulls, corncobs, cottonseed hulls, ground roughage, or other low-grade material. The analysis of many mixed feeds, however, does not give complete information concerning the composition—the sources of protein for instance—or the content of phosphorus and calcium. The open formula differs from the closed formula in that the statement of composition on the tag or sack also gives the kinds and quantities of the various ingredients used in the mixture. A person is thus better able to judge the value of the feed. If the analysis is satisfactory, if the variety of sources is ample, if the odor and appearance of the feed are good, and if the cows like it the requirements of a good feed are largely complied with.

COMPOUNDING THE GRAIN RATION

In compounding the grain ration several factors besides cost must be considered. They are the content of protein and minerals, bulkiness, and palatability.

PROTEIN CONTENT

The quantity of protein to be supplied in the grain depends upon the quantity of protein in the roughage. With only leguminous hay for roughage the grain should contain 12 to 15 per cent crude protein; with leguminous hay and silage or roots, 18 to 20 per cent; with nonleguminous hay alone or silage alone or a combination of both, from 23 to 25 per cent. Below are given grain mixtures grouped according to quantity of protein in roughage. It is impracticable to furnish perfectly balanced rations for all dairy cows because the requirements vary with the production. One of the most important objects in preparing a grain ration is to see that it contains sufficient protein from a number of sources so that every cow will be amply nourished. It is better to have some cows get more protein than they need than to attempt to supply a perfectly balanced ration for every cow.

Total crude protein 12 to 15 per cent. To be fed with legume hay or pasture	Total crude protein 18 to 20 per cent. To be fed with legume hay and silage or mixed hay alone	Total crude protein 23 to 25 per cent. To be fed with any kind of nonleguminous forage alone or with silage; with timothy and light clover mixed alone or with silage; with silage alone
100 pounds corn meal. 100 pounds ground oats. 100 pounds wheat bran.	100 pounds corn meal. 100 pounds ground oats. 100 pounds wheat bran. 100 pounds cottonseed meal.	100 pounds corn meal. 100 pounds ground oats. 100 pounds cottonseed meal. 100 pounds dried brewers' grains. 100 pounds corn-gluten feed.
200 pounds corn meal. 100 pounds ground oats. 100 pounds wheat bran.	200 pounds ground oats. 100 pounds corn-gluten feed. 200 pounds wheat bran. 100 pounds linseed meal.	100 pounds ground oats. 200 pounds wheat bran. 100 pounds linseed meal. 100 pounds cottonseed meal.
100 pounds corn meal. 200 pounds ground oats. 100 pounds wheat bran.	200 pounds corn meal. 100 pounds ground oats. 100 pounds cottonseed meal.	100 pounds corn meal. 100 pounds dried brewers' grains. 100 pounds wheat bran. 100 pounds linseed meal. 100 pounds cottonseed meal.
200 pounds corn-and-cob meal. 100 pounds wheat bran. 50 pounds cottonseed meal.	100 pounds corn-and-cob meal. 100 pounds ground oats. 200 pounds wheat bran. 100 pounds cottonseed meal.	

In general the following feeds may be used interchangeably in these rations: Corn meal, corn-and-cob meal, hominy feed, ground barley, and ground kafir; dried brewers' grains and corn-gluten feed; and cottonseed meal, linseed meal, peanut meal, and soybean meal.

MINERAL CONTENT

The minerals most likely to be deficient in the ration are common salt, calcium (lime), and phosphorus. Add common salt to the grain mixture at the rate of 1 per cent. In addition to this allow the cows access to salt at least once a day.

Although mineral mixtures are sometimes added to the grain ration, better results are obtained by making up the ration in such a way as to supply the needed minerals in the natural foodstuffs. None of the concentrates are high in lime. To provide this mineral, see that the cow receives plenty of legumes either in the form of pasture, soiling crops, or well-cured hay. If the grain ration contains a liberal proportion of wheat bran or some of the oil meals the needs of the cow for phosphorus will be met. Soils containing an abundance of lime and phosphorus will produce forage richer in these constituents than will soils deficient in them. For this reason liming

and fertilizing the soil will go a long way toward maintaining proper mineral nutrition of the dairy herd.

The feeding of inorganic mineral supplements containing calcium and phosphorus is advisable only under certain conditions. When cows are on grass pastures, especially if the soil is poor in lime or phosphorus or both, some benefit is derived from the feeding of steamed bone meal. Mix it with the grain at the rate of 1 or 2 per cent. If the cows receive no grain while on pasture, put the bone meal in a box where it will be accessible to the cows. In certain sections of the United States the soil is so deficient in phosphorus that the forage produced thereon when fed to dairy cows in the winter leads to serious malnutrition. This may be corrected by the feeding of steamed bone meal.

Steamed bone meal is valuable as a source of both calcium and phosphorus. Some bone meals are steamed more than others. The more the bone is steamed the less the quantity of organic matter left in it and the less odorous the product. The cows greatly prefer the bone meal which has been only slightly steamed, and for this reason it is the better form to use where cows have access to it at will. In any case the bone meal should be steamed sufficiently to destroy any disease-producing organisms which may be present. Since such bone meal spoils when it gets wet, the box containing it must be protected from the rain. When the bone meal is fed in the grain mixture its palatability is not a factor and therefore it makes no difference which form of the product is used.

The use of complex mineral mixtures is not advised since calcium and phosphorus, the only minerals likely to be deficient in the ration, can be obtained more cheaply in the materials mentioned than in the prepared mixtures. Raw rock phosphate may prove harmful because of its content of fluorine.

In addition to the minerals just mentioned, it is sometimes necessary to supply iodine in the ration. This can be done effectively by sprinkling on the feed of the pregnant cow once each week a tablespoonful of a 5 per cent solution of potassium or sodium iodide.

BULKINESS AND PALATABILITY

Some feeds when moistened become pasty, in which condition the digestive juices can not readily act on them. Combine such feeds with more bulky ones in order to prevent this condition. The best feeds for this purpose are wheat bran and ground oats. If the grain ration contains one-third to one-half of either or both of these two feeds it will not stick together when wet. Dried beet pulp or a ground roughage also may be used for this purpose. In some cases the concentrates are mixed with the silage at feeding time. Cobs are sometimes ground with the corn in order to provide bulk to the grain ration. Although the cobs do serve this purpose, they add very little nutriment.

Grain mixtures should be sufficiently palatable so that every cow will consume as much as is required for highest milk production. Fortunately, most concentrates of good quality are palatable. Among these are corn, barley, oats, wheat bran, beet pulp, and the oil meals. Velvetbeans, rye, coconut by-products, and some of the other uncommon feeds are lacking in palatability.

The use of molasses in a ration that is already palatable is as a rule not profitable. Cows will eat an unpalatable grain mixture more readily and a low-grade hay more completely, however, if molasses is poured over or mixed with the grain or hay. Before adding the molasses, mix with enough water to make the solution flow freely. Excessive quantities of molasses make the ration highly laxative. Usually 3 pounds per day for each cow is the maximum amount that can be fed with safety.

KINDS AND QUANTITIES OF FEEDS TO USE

In general, dairy cows should be fed all or nearly all the roughage they will consume either in the form of pasture grass, soiling crops, hay, or silage. The nutrients in such feeds are usually cheaper than those in concentrates, the cow's digestive system is primarily adapted to handling coarse feed, and cows generously fed on roughage rather than concentrates are less subject to digestive disturbances. If the dairyman buys both the hay and grain, however, and the hay costs more than one-half to two-thirds as much as the grain, he may well limit the quantity of hay and feed more grain. In feeding medium or low-producing cows such practice is safe and economical; in feeding high producers, however, care must be taken not to throw the cow off her feed by feeding concentrates too heavily. Such cows should receive enough nutrients in their roughages so that the grain allowance may be kept at a safe level.

SUMMER FEEDING

The herbage of an ideal pasture is young, tender, abundant, palatable, and grown on a soil rich in minerals, especially lime and phosphorus. Immature grass is more palatable than that which has reached the usual haymaking stage. This is well illustrated in many pastures where cows will be seen grazing on the spots of short grass rather than on that which has become more mature. Early in the spring, although the grass is tender and palatable, it should not be grazed until it has reached sufficient height so that a cow can gather her fill in a few hours. Deferring grazing until such time also results in a greater yield of pasture grass.

Pastures vary so much in quality that definite feeding recommendations are impossible. On good pasture cows producing 1 pound or less of butterfat a day maintain their production and body weight for about the first two months just as well without grain as with it. From this time on until fall additional feed must be supplied as the growth of grass becomes slower, the weather warmer, and the flies more annoying, resulting in a much diminished intake of grass. If the rainfall is sufficient to keep the pastures fairly abundant or if temporary pastures have been provided, probably grain alone will suffice as a supplementary feed. Under less favorable conditions, however, soiling crops, silage, or hay must also be fed. Where the pastures are exceptionally good they will support a production of more than 1 pound of butterfat a day.

In deciding on the kinds and quantities of feeds to be used in supplementing the pastures, the condition of the cows should also be taken into consideration. In most cases if the cows are allowed to become very thin, the result will be a much-reduced milk flow which

can not be regained during that lactation by a subsequent period of more liberal feeding.

Soiling crops are often used as supplements to short pastures and sometimes as substitutes for them. For the former purpose corn and to a lesser extent alfalfa, soybeans, or Sudan grass are the most universally used. Since these crops are rather generally raised on dairy farms, no special fields or extra attention are required. For these reasons they make the cheapest and best soiling crops for use in the late summer. When soiling crops take the place of pasture entirely a continuous supply of them throughout the summer must be provided, a fact which necessitates special crops or special seeding to fill the gaps between the crops regularly raised. The crops to be raised vary so much with the climatic and soil conditions that no specific recommendations are possible.

For summer feeding, where it is available, silage is generally cheaper and more convenient to use than soiling crops. Silage left over from the previous season may be used after the removal of the spoiled top layer, or an early-maturing crop may be ensiled and used as needed.

WINTER FEEDING

The winter ration should include at least one hay (legume preferred), one succulent feed, and grain. Give the cows all the good hay they will eat twice a day. If they will eat corn stover or straw in addition there is no objection to letting them have it. When fed with a medium quantity of silage, 1 to 1½ pounds a day of medium to good hay for each 100 pounds of live weight will be consumed. The same quality of hay fed without the silage will be eaten at the rate of about 2 pounds a day for each 100 pounds live weight. More nutrients are consumed when silage or roots are fed with the hay than when hay is fed alone.

In most sections of the United States, the cheapest, surest, and most satisfactory way to provide a succulent feed for winter use is by means of the silo. Where corn grows well it is the best crop to raise for silage. It yields heavily and makes a very palatable silage. In some sections of the South and in the Southwest some of the sorghums have a high enough yield to more than balance the better quality of corn silage. In sections too cold for the good growth of corn, oats and peas grown together or sunflowers make a fairly satisfactory substitute. Mixtures of corn or sorghum and a legume for silage are desirable only under conditions precluding the proper curing of the legume into hay. A mixture of corn and soybeans does not make a more palatable silage than corn alone, nor do the two crops grown together yield any more than corn alone. Besides, legumes are generally more cheaply made into hay than converted into silage.

The amount of silage to feed ranges from about 20 to 50 pounds per cow per day, depending upon the size of the cow and the quantity of other roughages fed. If hay is scarce or high in price, reduce the amount of hay and feed more silage. The usual quantity of silage advised is about 3 pounds per day for each 100 pounds of live weight.

Although root crops are low in fiber, do not feed them in place of concentrates, but, like silage, as a supplement to a ration of hay

and concentrates. The quantity of root crops to feed depends upon their cost as compared with that of other feeds, upon the kinds of roots, and upon the other ingredients in the ration. In general cows receiving some other succulent feed, such as pasture, soiling crops, or silage, do not need root crops. If root crops are expensive, feed only about 30 to 50 pounds a day. If relatively cheap, as may be the case in some regions, feed twice this quantity. More mangels and turnips may be fed than sugar beets or sweetpotatoes because they contain more water. Feed only moderate quantities of beet tops, because they are more laxative than the beets themselves. Beet tops as well as the root crops should be free from excessive dirt when fed.

Dried beet pulp soaked in about three times its weight of water makes a desirable feed to use in the absence of other succulent material. As compared with silage on the basis of nutrient content, beet pulp under most conditions is more expensive. The soaked beet pulp is also valuable as a feed for high-producing cows. Frequently the grain requirement for such cows is so high that the necessary quantity can not be fed without endangering their health. In such cases the quantity of grain may be kept at a safe level and the additional nutrients supplied by feeding soaked beet pulp.

Experiments at the dairy experiment farm at Beltsville, Md., show the following feeding practice to be a fairly satisfactory one: Feed each cow about 3 pounds of silage for each 100 pounds of live weight. A cow weighing 800 pounds, therefore, would receive 24 pounds of silage, whereas one weighing 1,200 pounds would receive 36 pounds of silage. Then twice a day give the cow all the good legume hay she will eat exclusive of coarse stems and weeds. To Jersey cows yielding 10 pounds of milk or less give no grain, but for every pound over 10 give 0.6 pound of grain. A Jersey cow giving 20 pounds of milk, therefore, would receive 6 pounds of grain; one giving 30 pounds of milk would receive 12 pounds of grain. To Holsteins yielding 16 pounds of milk or less give no grain, but for every pound over 16 give 0.4 pound of grain. A Holstein cow yielding 30 pounds of milk, therefore, would receive 5.6 pounds of grain, whereas one giving 40 pounds would receive 9.6 pounds of grain. Although this system of feeding has not been tried out with other breeds, it is probable that Guernseys should receive 0.5 or 0.55 pound of grain for each pound of milk above 12 and Ayrshires 0.45 pound of grain for each pound of milk above 14. If the hay is of poor quality the cows will not eat so much of it and therefore must receive more grain. On the other hand if the hay is of the best quality the cows will eat more of it, and less grain than specified will be required. Where the roughage is the very best, a cow may produce 1 pound of butterfat daily or even more on roughage alone, without losing weight. The above directions are based on the supposition that the cow eats 1¼ pounds of hay per day for each 100 pounds of live weight. In the absence of exact weights, a feeder must be guided largely by the condition of the individual cows. If any are getting thin, give them more grain; if they are getting fat, reduce the grain. For most economical production, cows should be kept in a medium state of flesh, neither fat nor thin.

Record the quantity of feed consumed by each cow. A convenient and practical way to feed concentrates is to use a cart or truck (fig. 2) to which is attached feeding charts or cards showing the amount of feed to be given each cow. A small blackboard can be attached to the cart and the figures recorded. A spring-balance scale suspended above the cart on an arm is of great help. If the allowance of silage and hay is weighed occasionally, the quantity can be measured with reasonable accuracy.

BEFORE AND AFTER CALVING

The cow that has been dry for six weeks to two months and that has been liberally fed while milking, as well as during the dry period, should be in good flesh at calving time. Several days before the

FIGURE 2.—Concentrates should be fed according to production

cow calves, reduce the quantity of silage and hay slightly; and if any grain is being fed, cut it down to 3 or 4 pounds daily. Ground oats mixed with wheat bran and linseed meal are good feeds to give at this time. The drinking water should not be too cold. For several hours before calving, feed the cow very little hay or silage. A warm bran mash at this time is very beneficial.

For a few days after calving, continue to feed sparingly. This will help to prevent digestive disturbances and to reduce the swelling in the udder. In general, after calving the appetite of thin cows is somewhat keener than that of fat cows, and their udders reach normal size in a shorter time. For these reasons thin cows may gradually be put on full feed in about two weeks as compared with four or more weeks for fat cows.

After a cow has been fresh from three to six weeks, her weight has usually reached the minimum and her production the maximum. Feed her enough to maintain her body weight; otherwise the production of milk will decrease rapidly. She should make a slow but steady gain in weight from this time until she calves again in order to bring her to the same condition as the previous year. The total gain, including the weight of the fetus, should be from 100 to 250 pounds, depending upon the breed and condition of the cow. It is better to feed her enough to allow some of this gain to be made while milking rather than to try to accomplish it all during the dry period. Such feeding will undoubtedly result in more milk than if the weight is kept stationary. The feeding practice recommended above will furnish sufficient nutrients for cows to make a slight gain but still not enough to bring them back to proper weight before drying off. Some of the flesh must be put on when cows are dry.

FEEDING SUGGESTIONS

In planning the winter ration, provide at least one hay (legume preferred), one succulent, and a concentrate mixture containing three grains.

The order of feeding roughage, succulents, and concentrates has no effect on milk production.

Feed concentrates as often as the cow is milked. Roughage and succulents may be fed twice a day.

Feeding concentrates wet has no advantage over feeding them dry.

Always grind or roll grain for dairy cows.

Soak at one time only as much beet pulp as can be fed in 24 hours.

Cows will eat more of a coarse, stemmy hay if run through a cutter, although the digestibility of the feed is not affected.

Grinding hay or other dry roughage does not pay.

There is no advantage in mixing ground roughages and ground concentrates except that a small quantity of ground roughage may be used to lighten a heavy ration of concentrates.

Corn fodder cut and treated with a converter, which changes some of the starch to sugar, has been found to possess no advantage over corn silage in cost, palatability, or quantity of milk produced.

Always feed highly flavored feeds just after milking. It is advisable also to do all the feeding at this time.

Immediately after a cow has calved, give her a small quantity of a warm bran mash.

Before feeding such feeds as root crops, potatoes, and apples, run them through a feed chopper.

Shredding corn stover adds to the convenience in feeding and makes it better bedding.

A cow not in good condition because of disease may be helped by a tonic. The tonic is a medicine and should be used as such. A healthy, well-fed cow needs a tonic no more than a healthy person needs medicine.

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